THE DEVELOPMENT OF A GaAs MMIC RELIABILITY AND SPACE QUALIFICATION GUIDE

George E. Ponchak
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

Sammy Kayali
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA 91109

Ho-Chung Huang
COMSAT Laboratories
Clarksburg, MD 20871

ABSTRACT

NASA, JPL, and DOD are collaborating with GaAs MMIC users, manufacturers, and international space agencies (o develop the "GaAs MMIC Reliability and Space Qualification Guide." This paper discusses the need for a space qualification guide, provides a brief description of some common GaAs failure mechanisms, the approach that the NASA MMIC Reliability Assurance Program is following to develop the guide, and the status of the program.

INTRODUCTION

Direct broadcast television, interactive video services, telemedicine, mobile/personnel communications, and hubless VSATS are some commercial applications of satellites being proposed. In addition, the DOD and NASA will continue to use satellites for communications, global positioning, planetary exploration, and radiometry for the Mission to Planet Earth.

For applications below 2 GHz, Si circuits provide satisfactory RF performance, but for applications above 2 GHz, GaAs devices possess superior performance. Furthermore, GaAs MMICs are a promising and viable solution to the higher complexity, smaller size, and lower cost that are required in all of the proposed satellite systems. Specifically, multibeam antennas, phased array antennas, switch matrices, power amplifiers, and beam forming networks will all require MMICs.

An example of GaAs usage in satellites is the In Orbit Test Transponder (IOTT) shown in Figure 1 from the ITALSAT 1 satellite (Agenzia Spatiale Italiana, Italy) that was launched in January 1992. This IOTT employs a discrete GaAs FET power amplifier as a transmitter and a X-band GaAs FET MMIC driver amplifier. Other commercial satellites that arc being planned or have recently been launched that use GaAs devices or circuits are ANIK (Telesat, Canada), AUSSAT (Australia), GSTAR (GTE Spacenet, US), INMARSAT, INTELSAT, N-STAR (NTT, Japan), PANAMSAT (Alpha Lyracom, US), SATCOM (GE Americom, US), SUPERBIRD (Space Communication Corp., Japan), TELSTAR (ATT, US), IRIDIUM (Motorala, US), ODYSSEY (TRW, US), and GLOBALSTAR (Loral Cellular Systems Corp., US). Some NASA missions that require GaAs MMICs arc CASSINI, Pluto Fast Flyby, MESUR, and Space Station Freedom.

Although there arc many GaAs circuits already in space, there is no standard space qualification procedure that is accepted by the GaAs community. Currently, each MMIC user negotiates with the MMIC manufacturer over the type of screens, the amount of testing, and the documentation necessary for each MMIC purchased. Often, screens and tests are. used that were not developed from an experience with or a knowledge of GaAs but from Si IC failure mechanisms. Furthermore, new GaAs failure mechanisms are being recognized that arc not properly screened. One example is the degradation of power output found in GaAs power devices after only a few hundred hours of operation. This failure mode was observed in solid state power amplifiers intended for INTELSAT, INMARSAT, and the Air Force DISC satellites.

The development of a reliability guide for GaAs MMICs that proposes strict qualification tests and standards is difficult. GaAs is still a young technology that is constantly evolving. GaAs MMIC manufacturers continuously change the device layout, material systems, and fabrication processes to improve the circuit performance and to reduce costs. This flexibility is critical for the manufacturers so that they may continue to develop higher performance and lower cost circuits which the customers require. It is also critical that both the manufacturers and the users of GaAs MMICs understand GaAs failure mechanisms and how qualification tests may be used to determine the reliability of the MMIC.

To address the need for a GaAs MMIC space qualification standard, NASA Code QW initiated a program to develop the "GaAs MMIC Reliability and Space Qualification Guide." NASA, JPL, and DOD arc collaborating with GaAs